Photonics 4 Precision Manufacturing

Industrial Micro-materials Processing Applications with Fiber Lasers

Wednesday, 15.06.2016, Palexpo Genève

The Power to Transform®

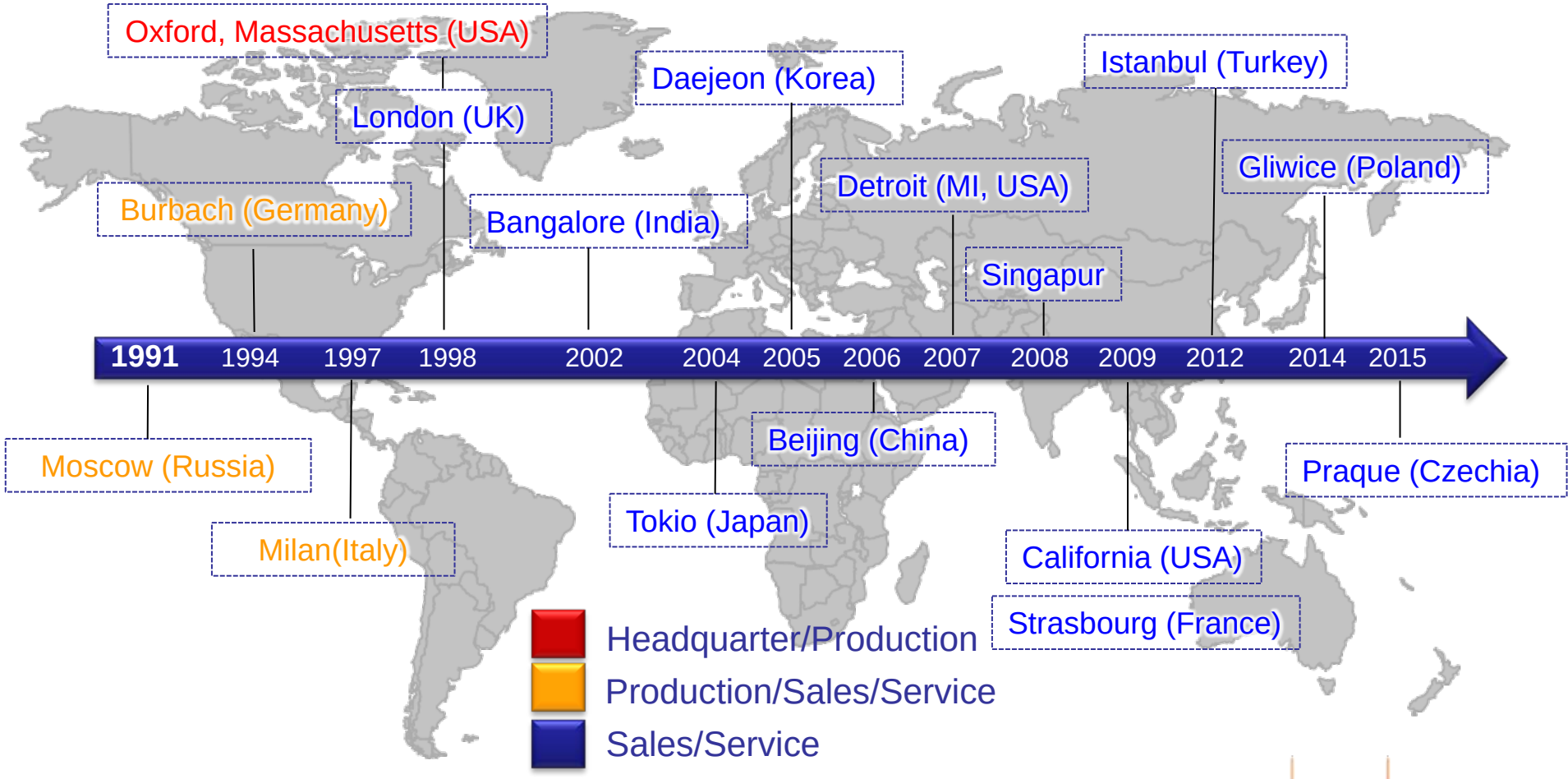
Tim Westphäling

IPG Laser, Burbach Germany

- IPG Overview
- Single Mode
- QCW
- Short pulse Laser
- Outlook & Conclusion

IPG Photonics Overview

Historie IPG Photonics

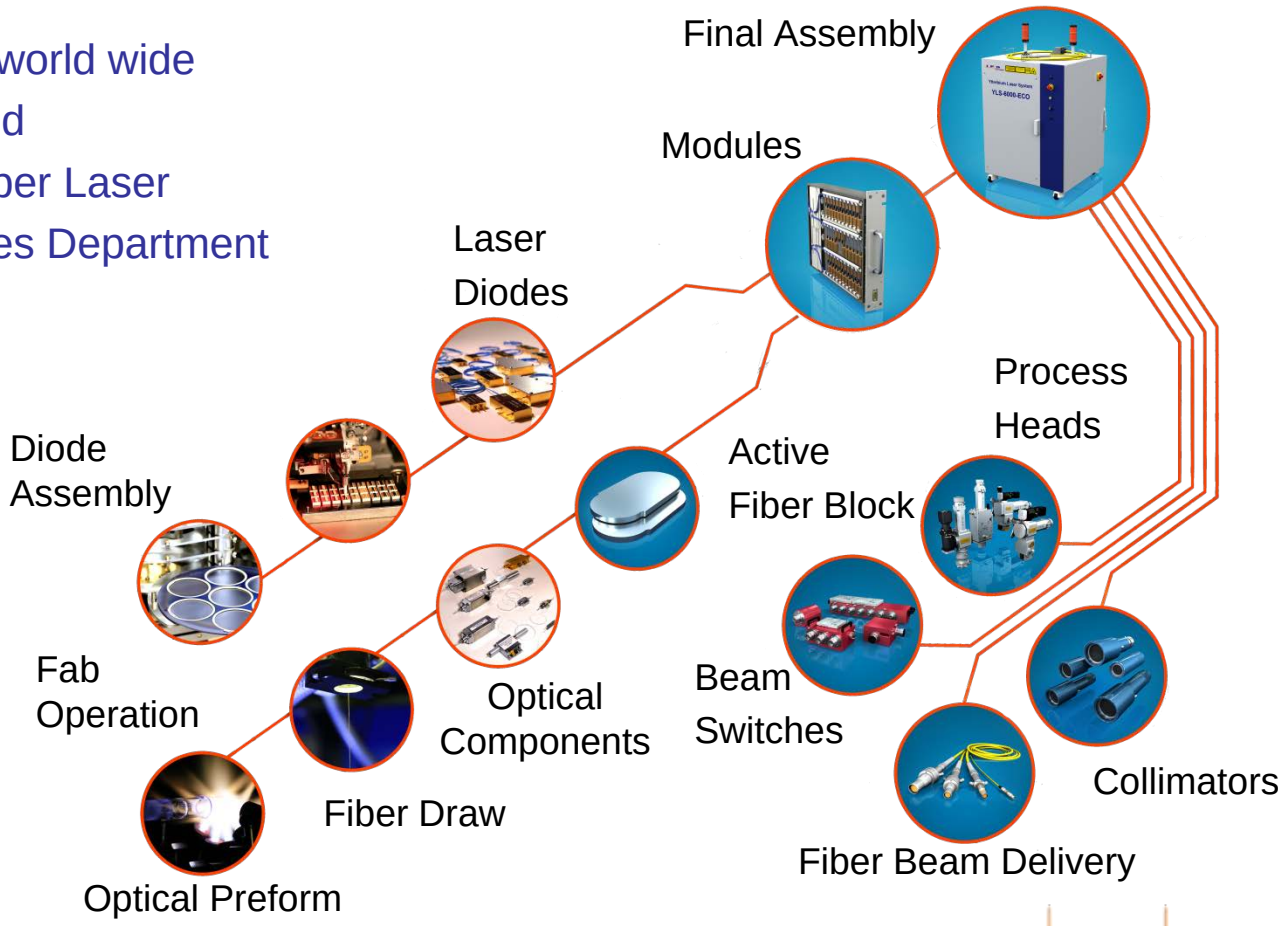


IPG Photonics Overview

General data IPG Photonics

- 3800 employee world wide
- Development and Production of Fiber Laser
- Service and Sales Department
- Application lab

Vertically Integrated Production

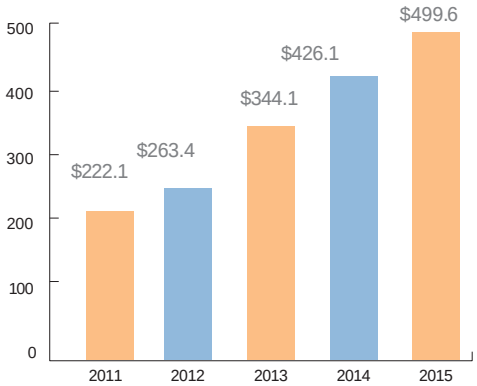


IPG Photonics Overview

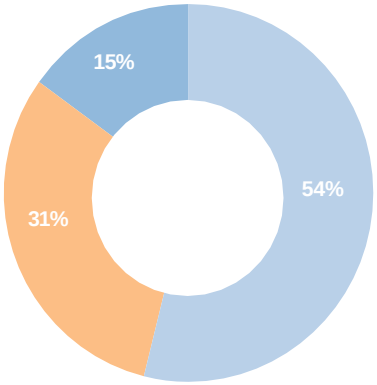
General data IPG Photonics

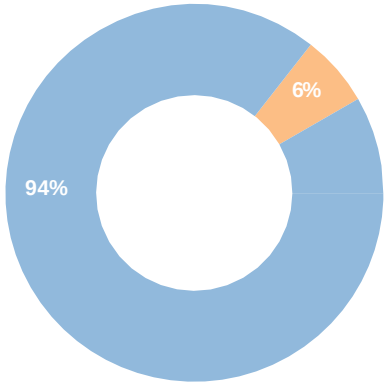
- Founded in 1991
- 17% year-over-year increase
- 800 employees more in 2015
- Total net sales 901 million $

High Power Laser Sales
(in millions)



2015 Sales by Geography and End-Use





- Asia
- Europe, CIS
- Americas

- Materials Processing
- Advance Applications, Medical, Telecom

Source: IPG Photonics Annual Report 2015

Application Field of Fiber Laser

Overview

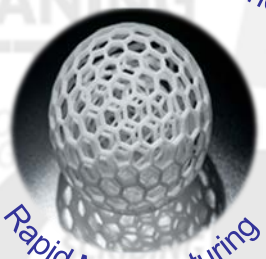

Photovoltaics


Advanced and Scientific


Medical Procedures


Power Plant


Medical Device


Rapid Manufacturing


Heavy Industry and Transport

IPG LASER

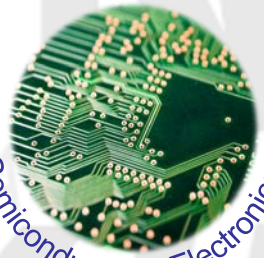

Entertainment & Projection Display


Oil & Gas


Consumer Electronics and Appliances


Aerospace


Automotive


Semiconductor & Electronics


Telecommunications

IPG PHOTONICS

IPG Product line

Overview Laser

Low Power CW Fiber Lasers

Mid Power CW Fiber Lasers

High Power CW Fiber Lasers

Quasi-CW Fiber Lasers

Nanosecond Fiber Lasers

Pico & Femtosecond Fiber Lasers

Mid-IR Hybrid Lasers

CW Fiber Amplifiers

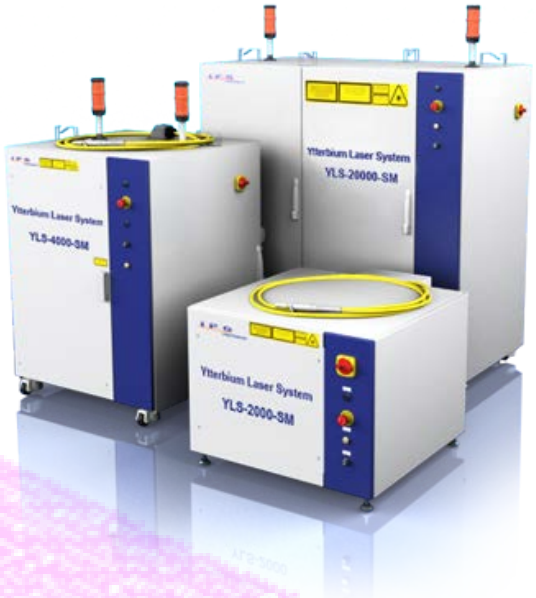
Diode Lasers

Single Mode Laser in Micromachining

Single Mode Fiber Laser(CW)

- Precision Cutting
- Remote Applications
- Accurate Welding

High Power 1 kW – 20 kW



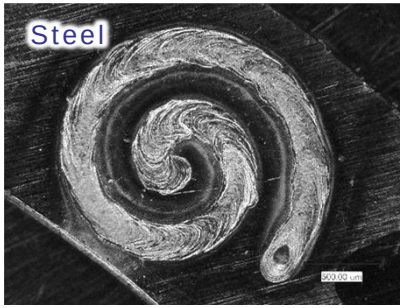
Mid-low Power < 1 kW

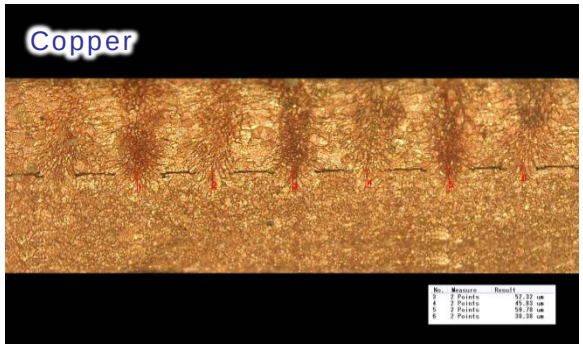
Single Mode Laser in Micromachining

Single Mode Fiber Laser(CW)

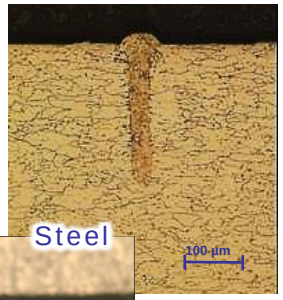
Application Example

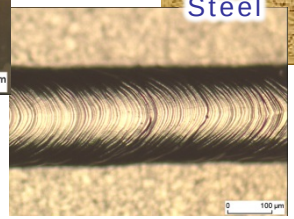
Accurate Welding





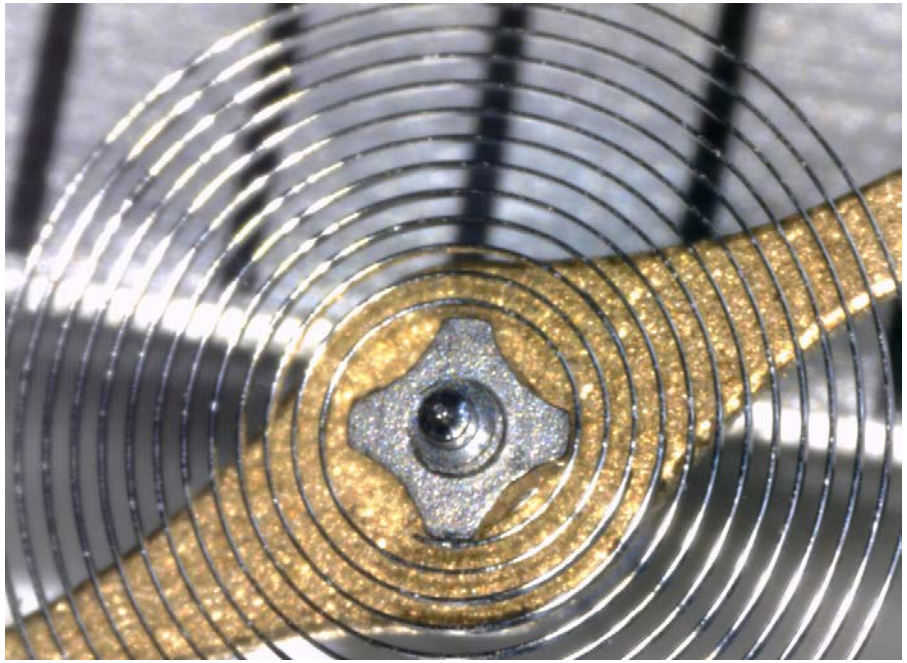
Foil Welding

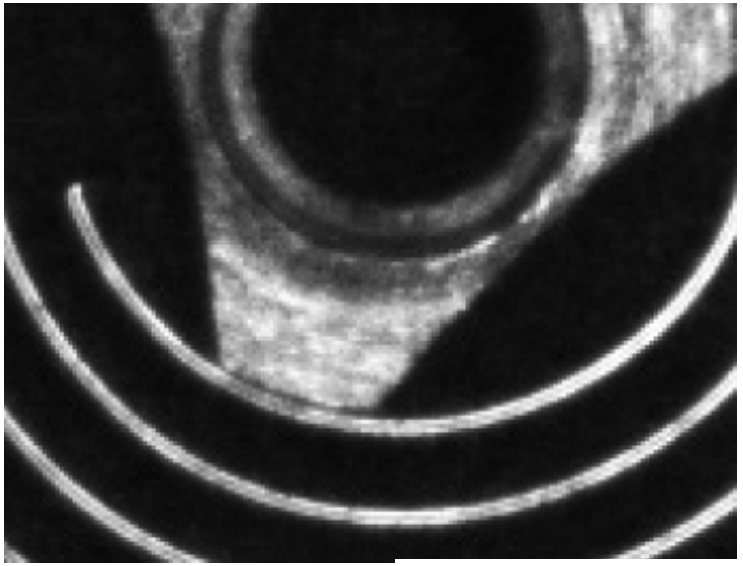




© BIAS, Deutschland

Spot welding of watch parts





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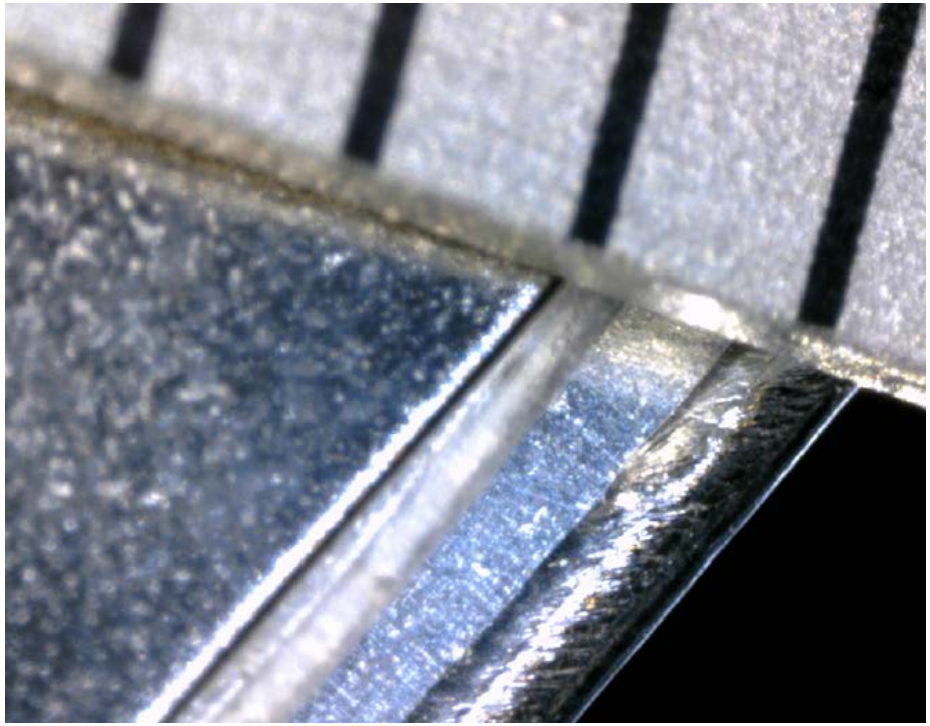
Seam welding of Batteries



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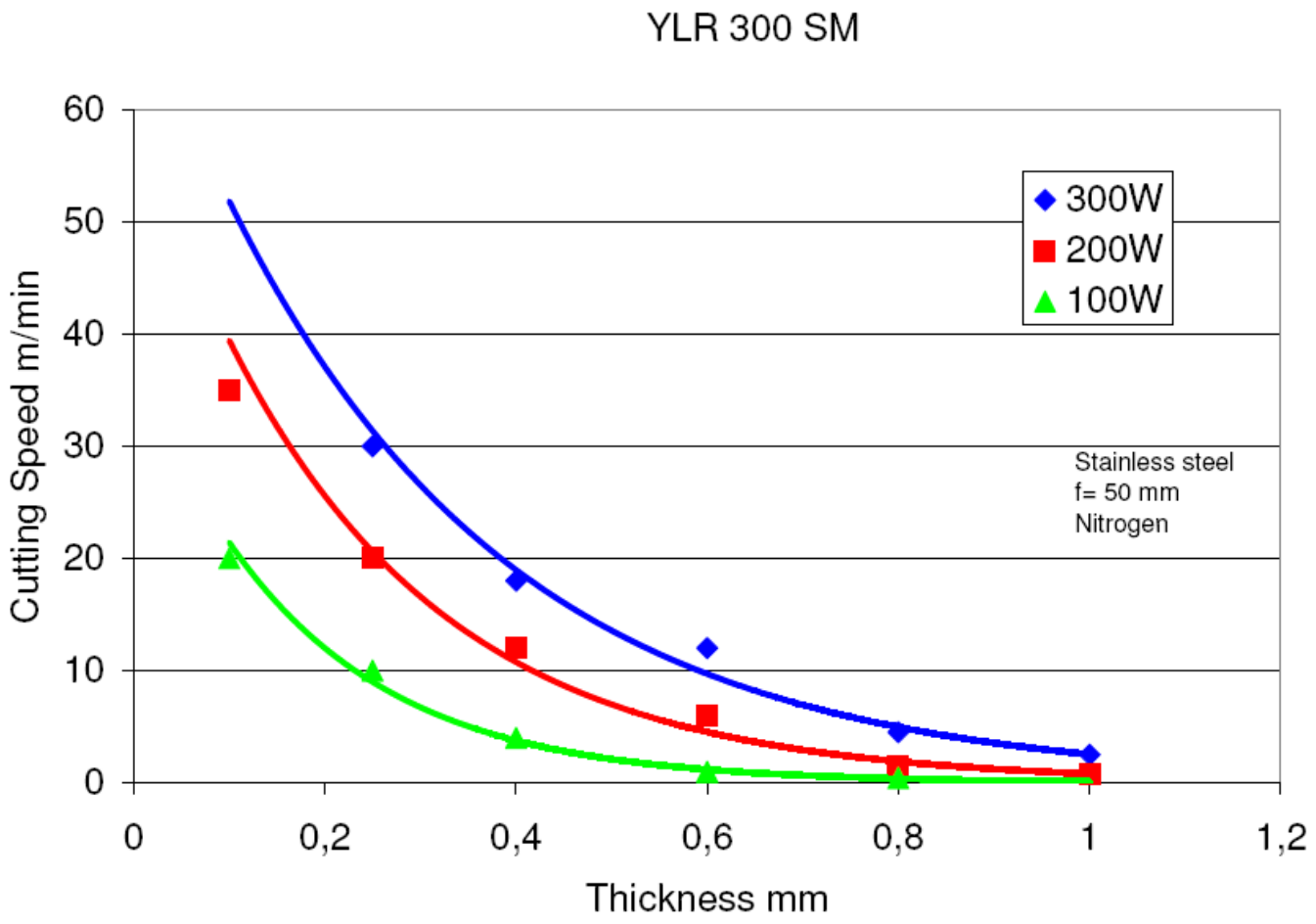
IPG PHOTONICS

Fine Cutting with 100 – 300 Watt

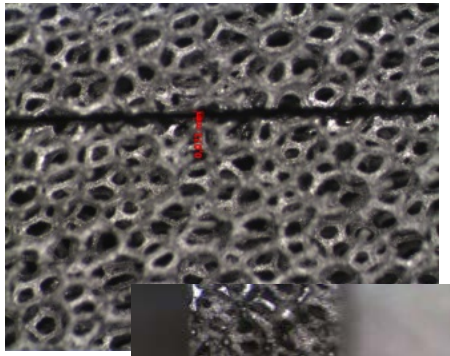


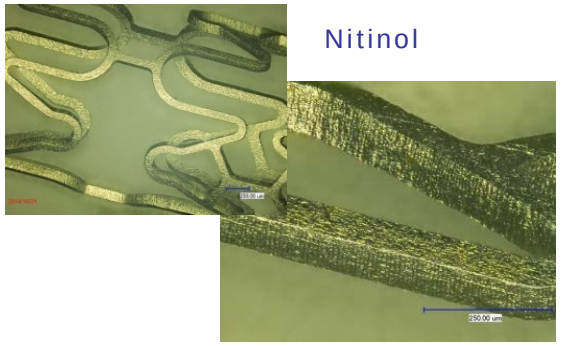
Single Mode Laser in Micromachining

Single Mode Fiber Laser(CW)

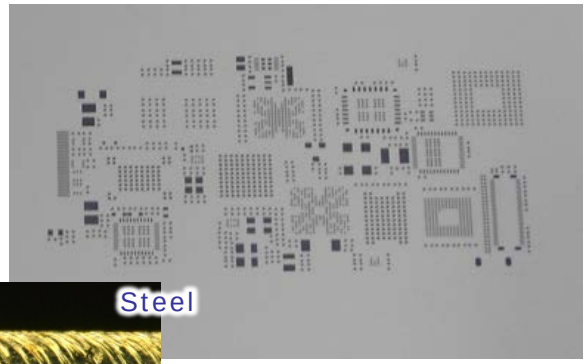
Application Example

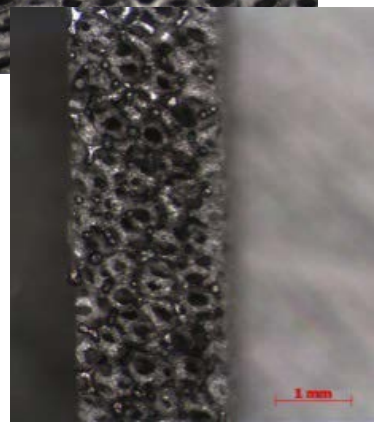
Fine Cutting

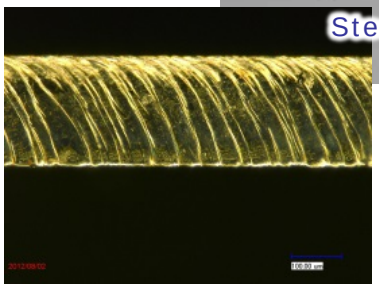




Nitinol

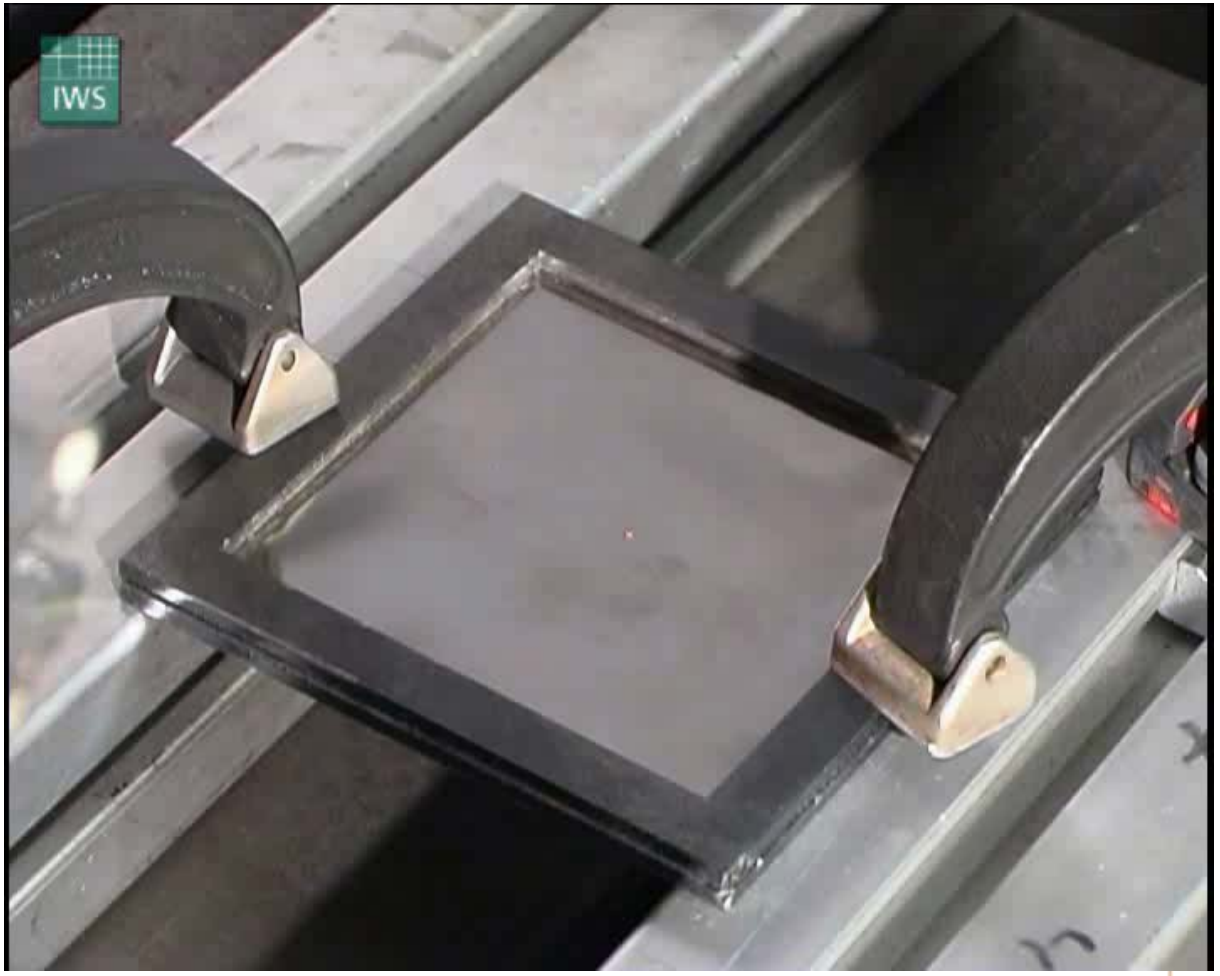




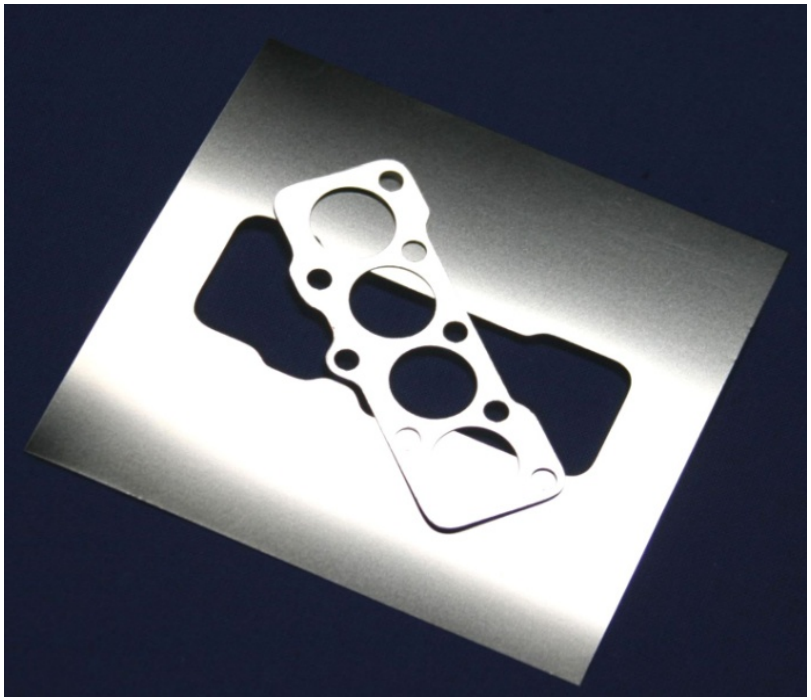


Steel

Remote Cutting Metals

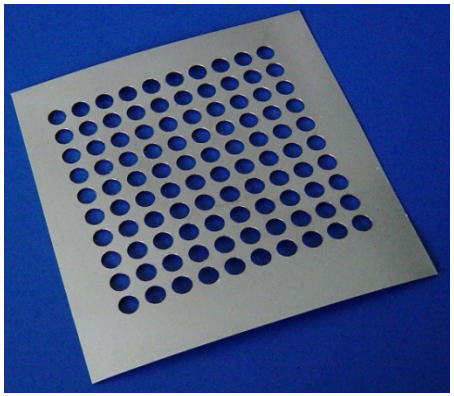


Remote Cutting Metals - Examples

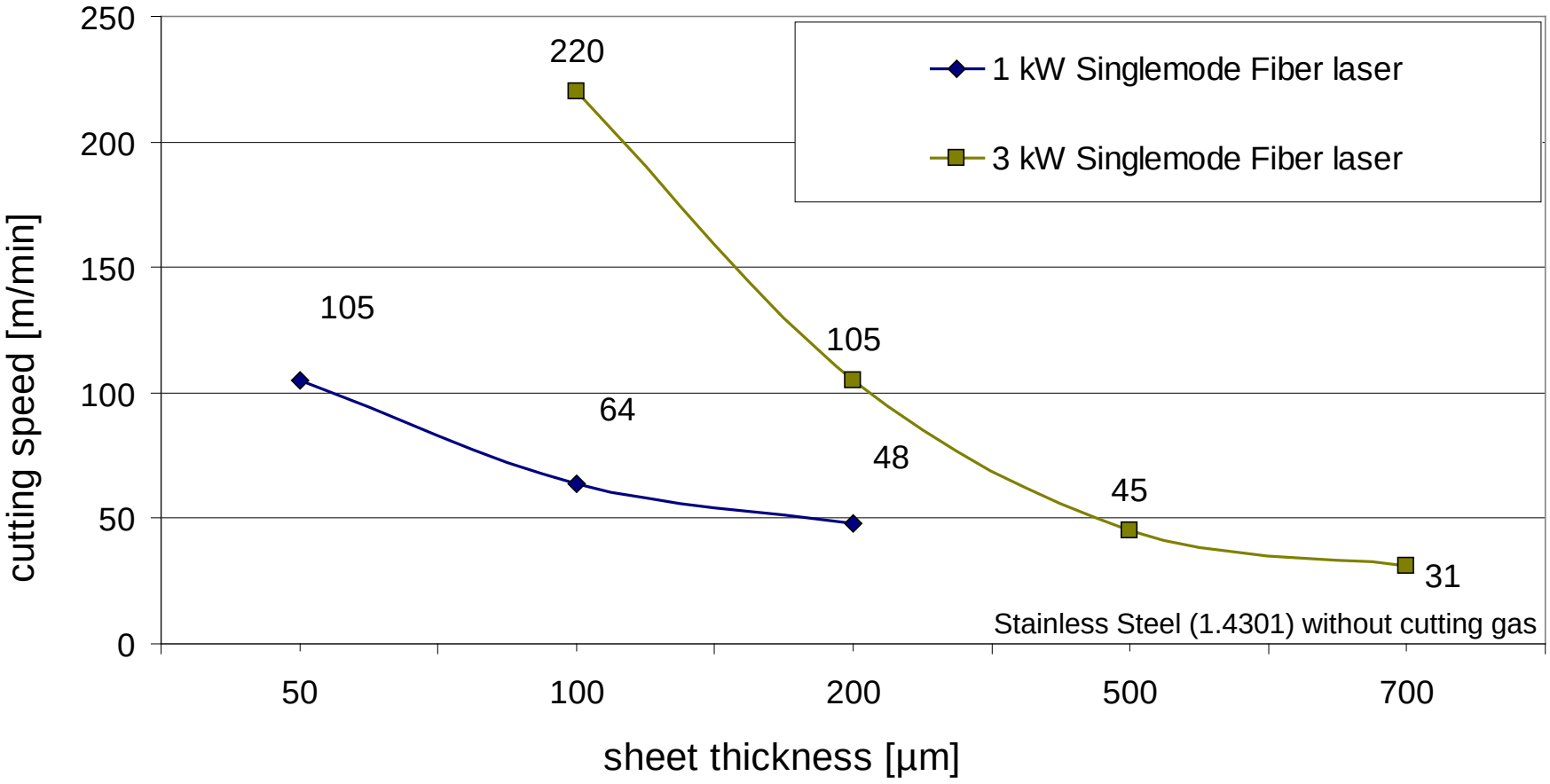


Micro punching applications:

- automotive
- electronics
- medical industry
- precision mechanics
- gaskets
- etc.



Remote Cutting Speeds

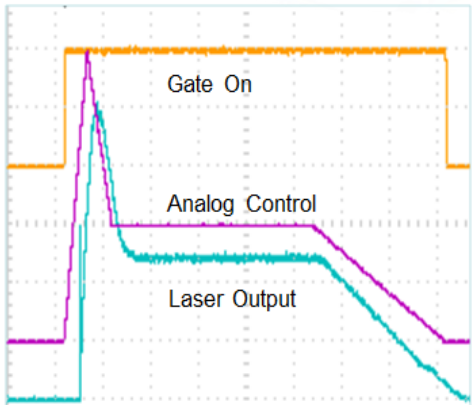


source: IWS

Pulsed Fiber Laser in Micromachining

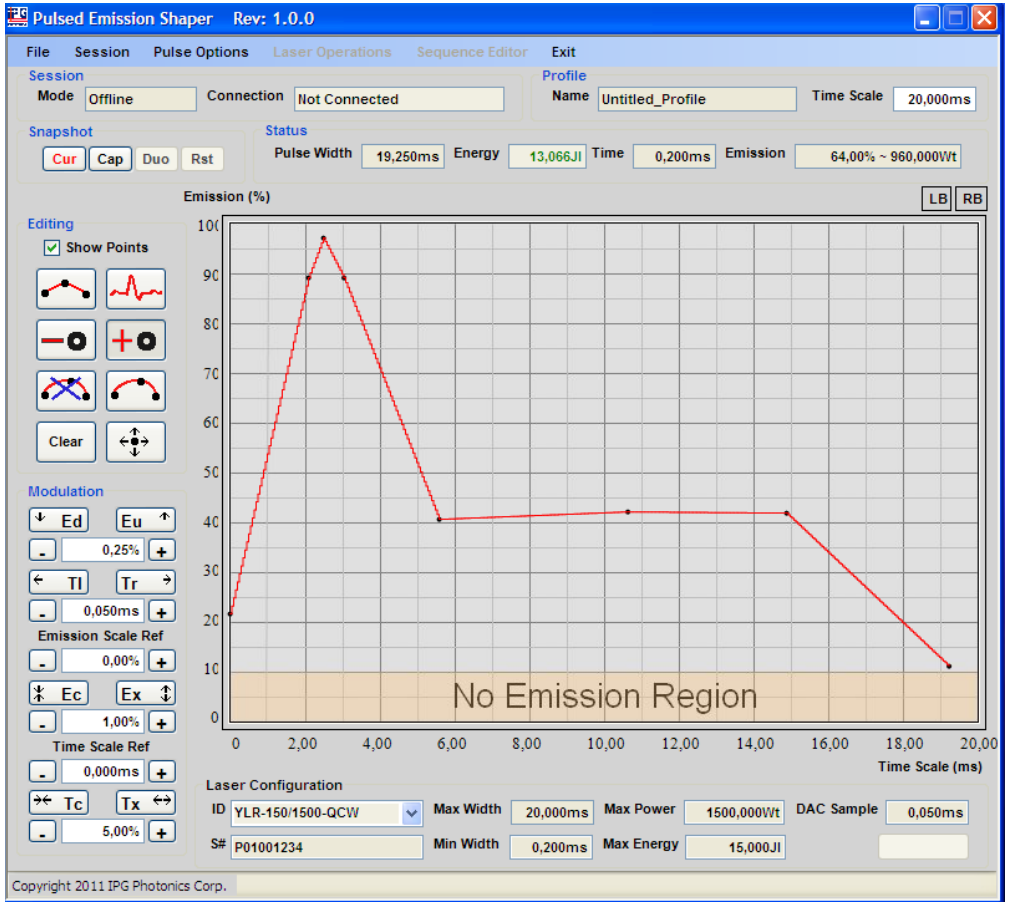
QCW Laser

- Drilling
- Cutting
- Spot Welding
- Batteries
- Seam Welding
- Medical Devices
- Micro welding
- Computer Components
- Deep Engraving



Average Power	Peak Power
150 W	1500 W
300 W	3000 W
450 W	4500 W
600 W	6000 W
900 W	9000 W
1200 W	12000 W
1500 W	15000 W
1800 W	18000 W
2000 W	20000 W
2300 W	23000 W

Beamshaping Software



Pulsed Fiber Laser in Micromachining

QCW Laser

Application Example

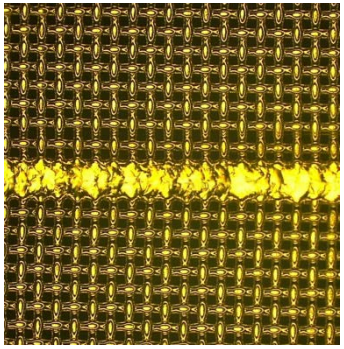
Pulsed Welding

- Sealed welding
- Pulse shaping
- Low HAZ

Membrane

Thermosta

Grid Welding



Pacemake

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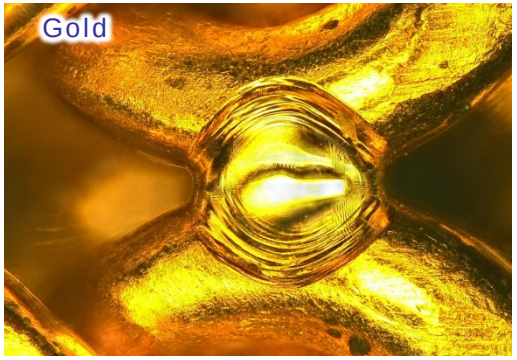
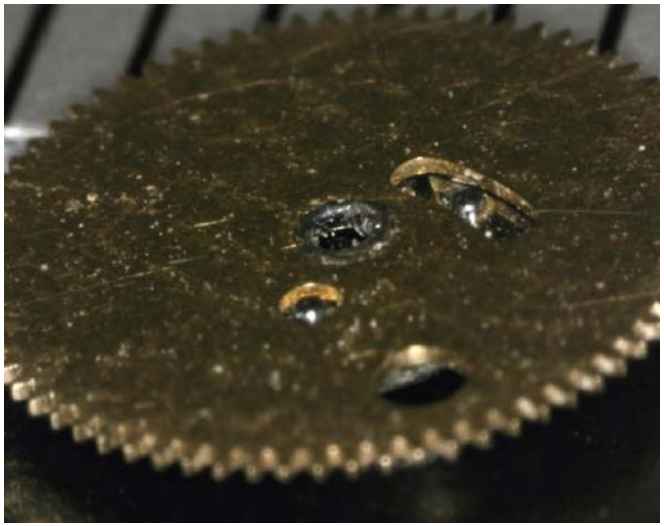
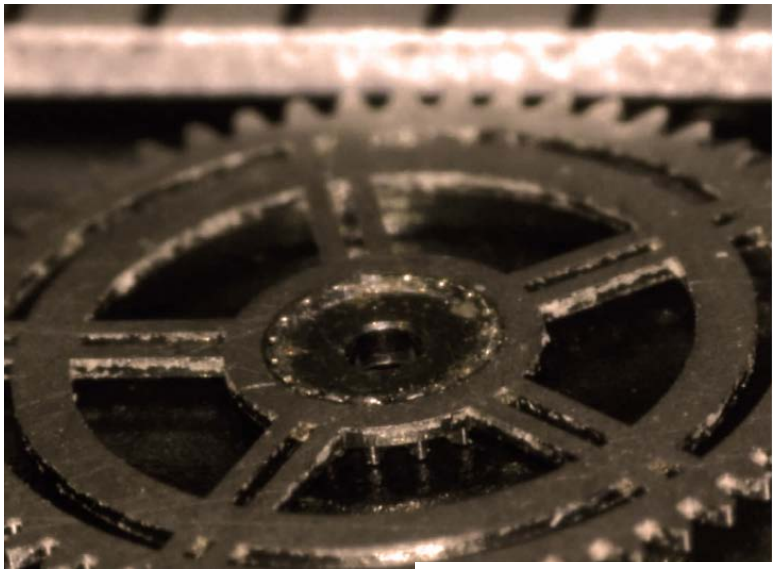
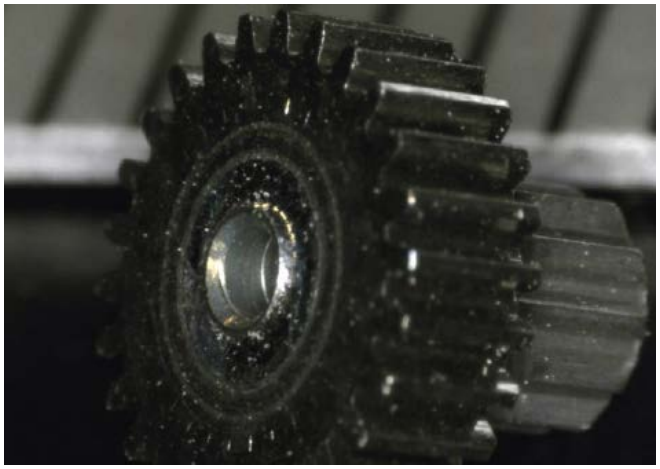
Decorative



Spot welding of watch weels







bs optics

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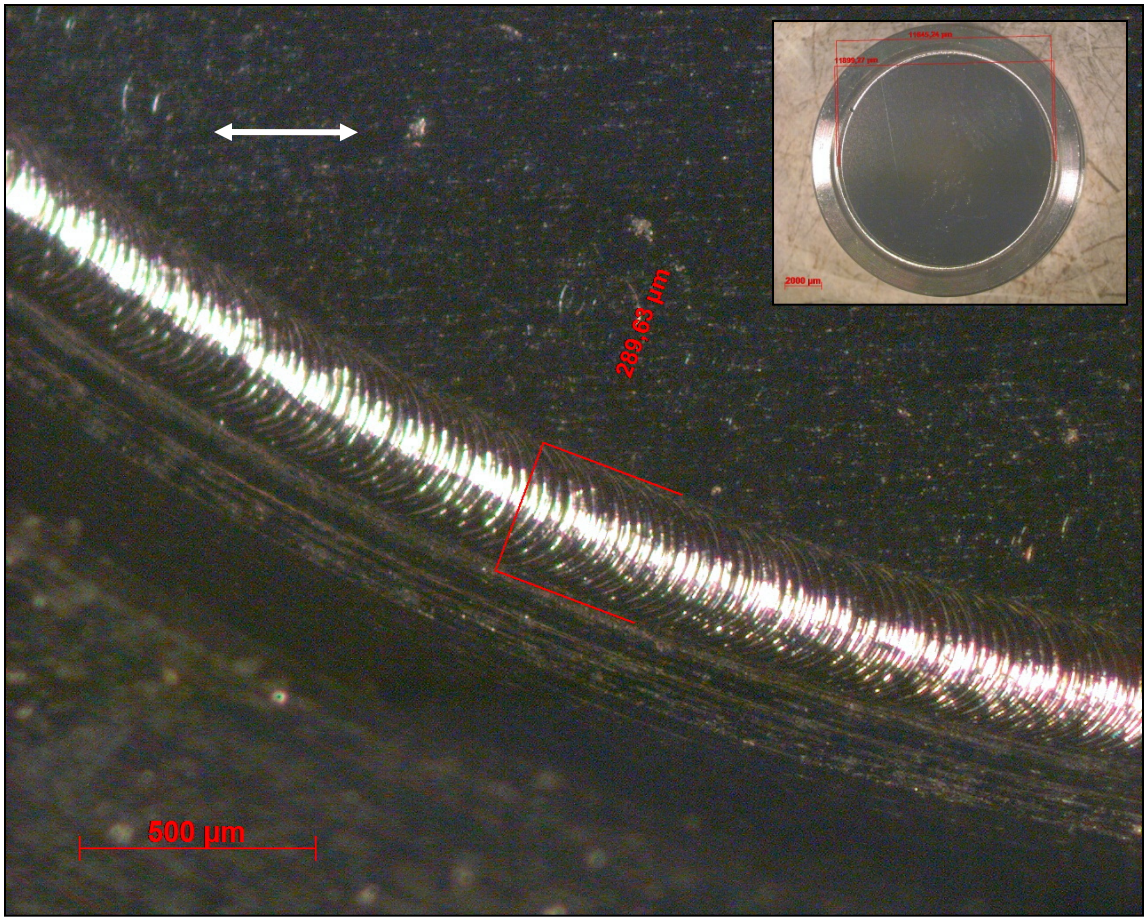
Seam Welding of pressure sensors (diameter 12 mm)



Laser:	**YLR-150-1500-QCW-AC**
Material:	stainless steel, 20 µm
Parameter:	50 µm fiber
	200 mm/min

Copyright IPG Photonics

Pulsed Fiber Laser in Micromachining

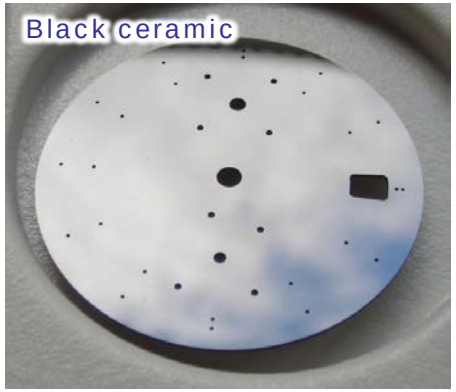
QCW Laser

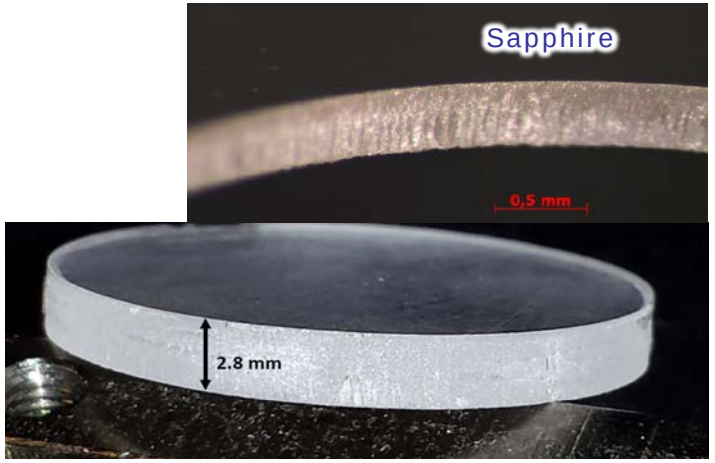
Application Example

Pulsed Cutting

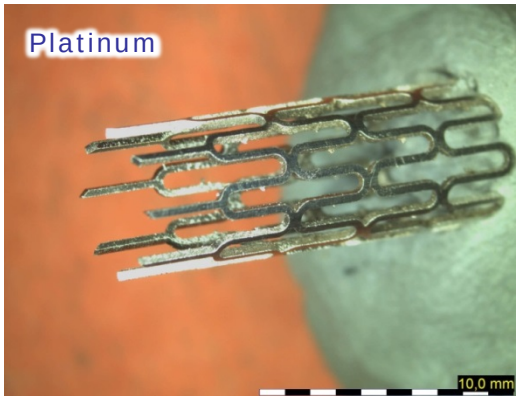
- Accurate Cutting
- Pulse shaping
- Low HAZ
- Cutting of different material

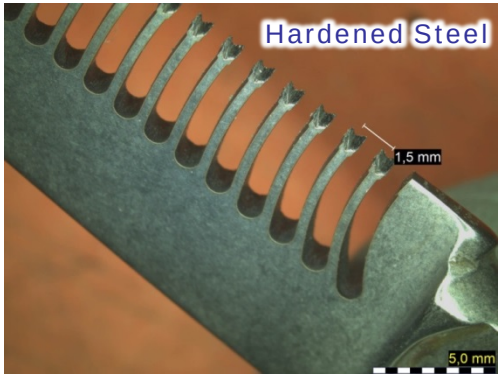
Watch





Stent





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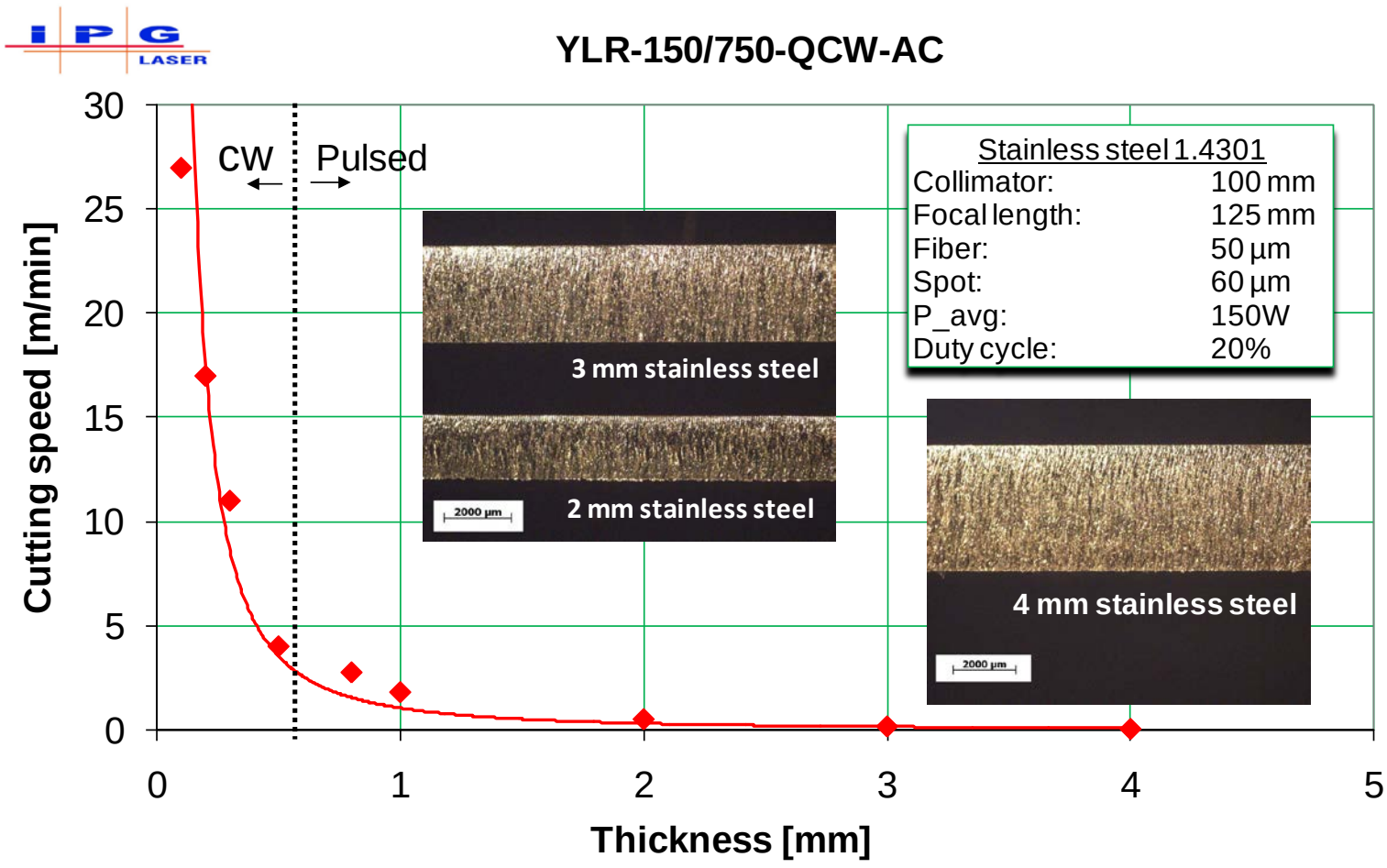
CW and Pulsed with One Device

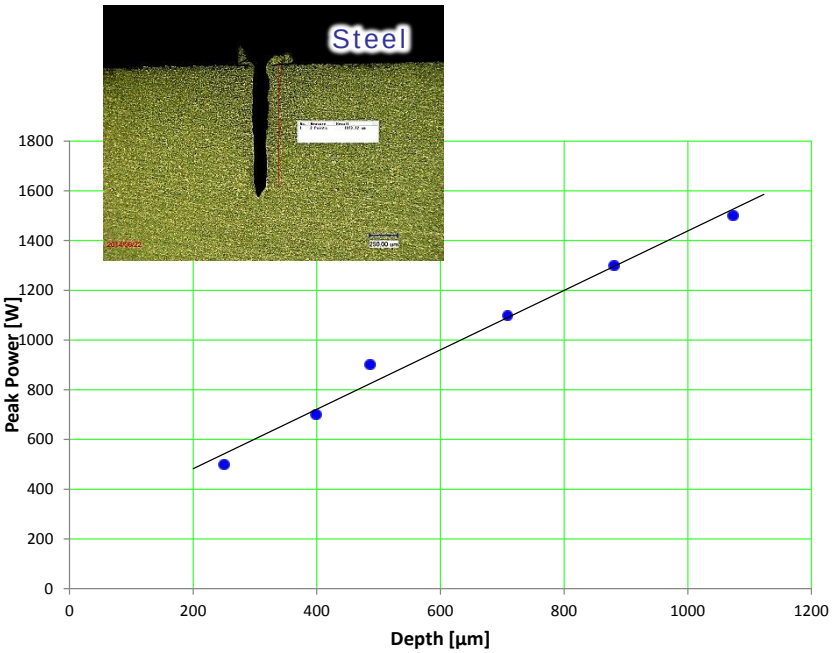


Pulsed Fiber Laser in Micromachining

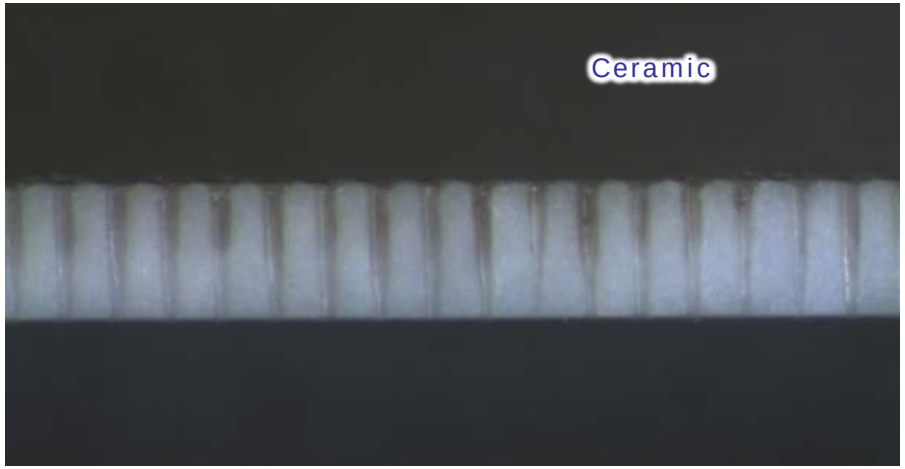
QCW Laser

Application Example

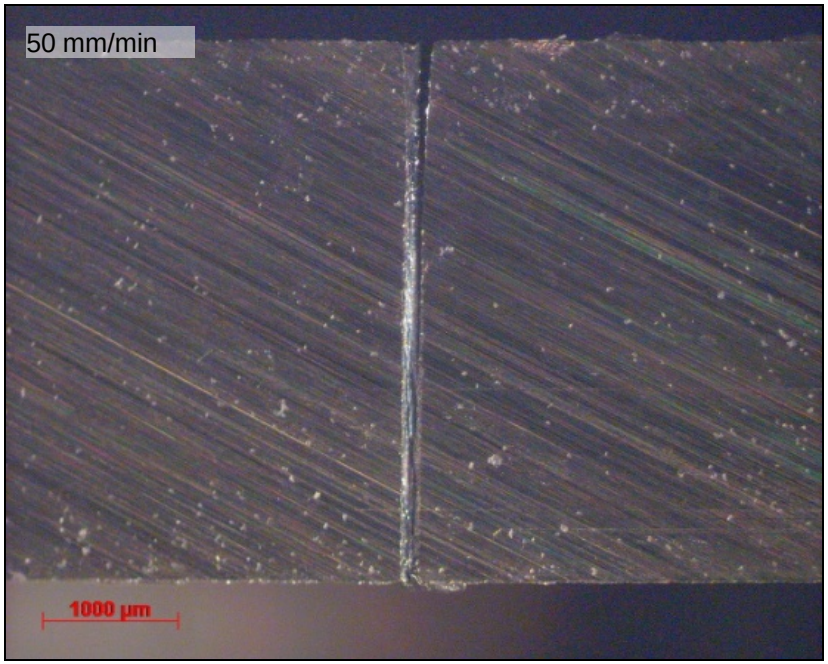
Deep Engraving



Drilling



Percusion drilling



Aspect ratio > 20

Laser:	**YLR-150-1500-SM-AC**
Optic:	**73:100 mm**
Material:	**Stainless Steel, 4 mm**
Parameter:	**500 Hz, 0.3 J, 200 µs**
Avr. Power:	**150 W**
Hole size:	**250 µm entrance**
	200 µm exit
Drilling time:	**1-10 s**

Pulsed Fiber Laser in Micromachining

YLP-V2/V3 series overview

- Average power 10/20/30/50/100 W
- Pulse energy 1mJ
- Pulse repetition rate 2…200 kHz
- Pulse duration 100 ns
- Beam diameter 7.5 mm
- Beam quality M2 <2
- Delivery fiber length 3 m
- Operating wavelength 1064 nm

YLP-V2

YLP-V3

- Bitstream 1 operating mode (instant emission ON/OFF)
- Built-in RS232C interface
- Extended PRR down to 2kHz
- Full factory pre-calibrated

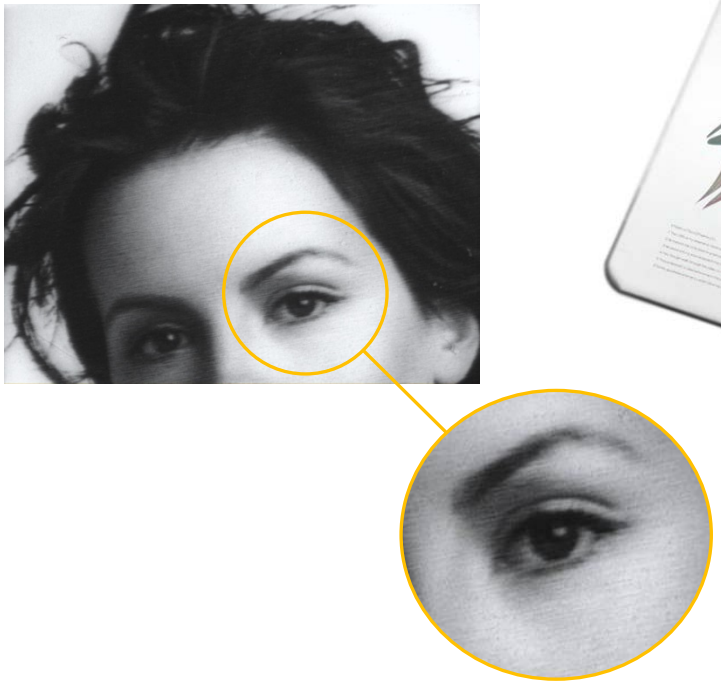
Pulsed Fiber Laser in Micromachining

YLP-V2/V3

Application Example

Marking

Grayscale marking



Color marking

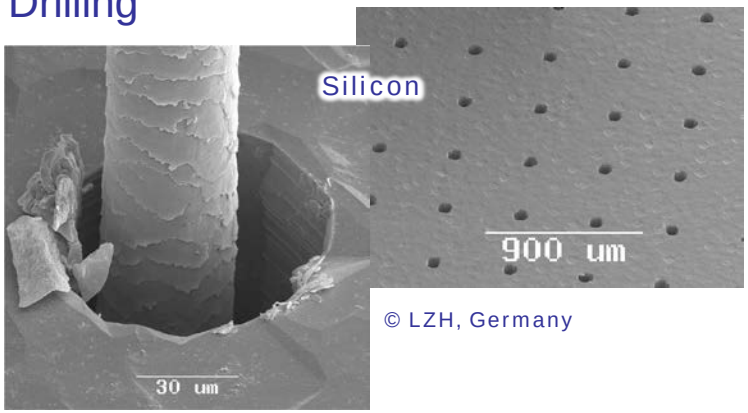
Marking of different Material

Pulsed Fiber Laser in Micromachining

YLP-V2/V3

Application Example

Drilling



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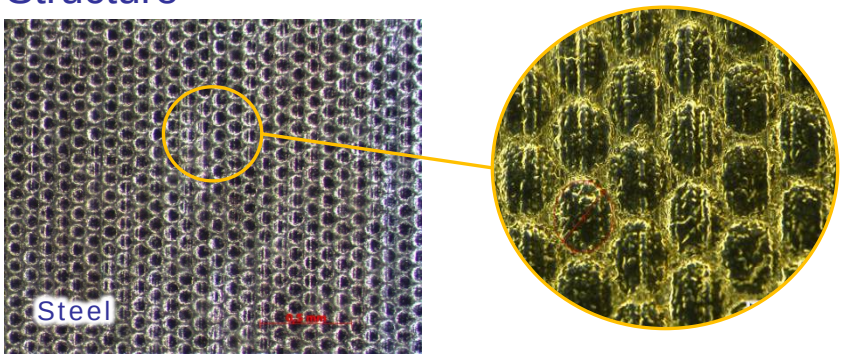
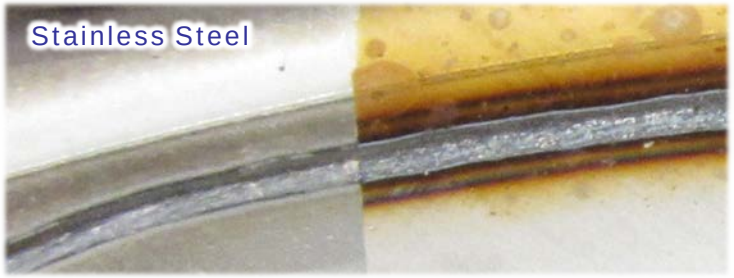
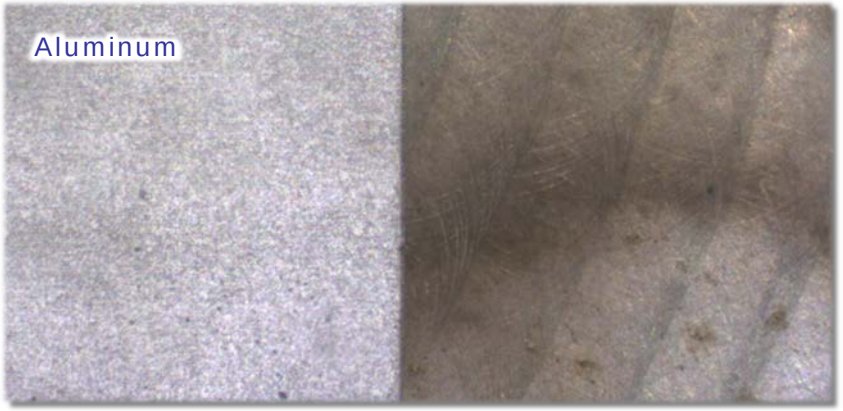
Structure



Dust cleaning



Surface finish



Pulsed Fiber Laser in Micromachining

MOPA (Master Oscillator Power Amplifier) Series Overview

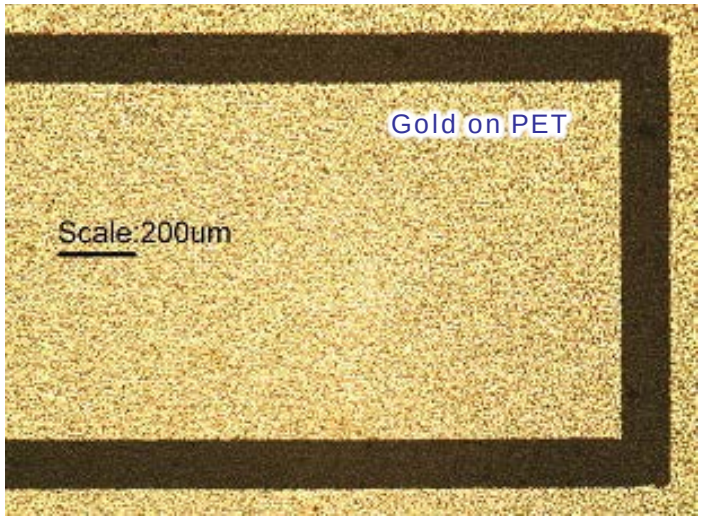
	YLPN-1-4x200	YLPN-1-1x120
• Average power	10/20/30 W	30/50/100 W
• Pulse energy	0.5/1 mJ	1 mJ
• Pulse repetition rate	1.6...1000 kHz	2…12000 kHz
• Pulse duration	4-200 ns, adjustable	1-120 ns, adjustable
• Beam diameter	7.5 mm	7.5 mm
• Beam quality M2	<2	<2
• Delivery fiber length	2 m	2 m
• Operating wavelength	1064 nm	1064 nm

Pulsed Fiber Laser in Micromachining

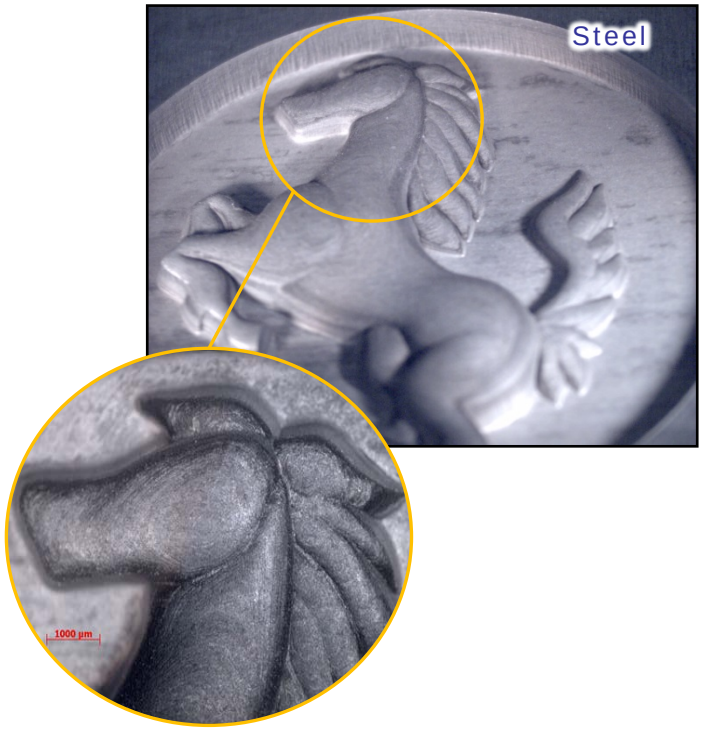
MOPA (Master Oscillator Power Amplifier)

Application Example

Patterning



Precise Ablations

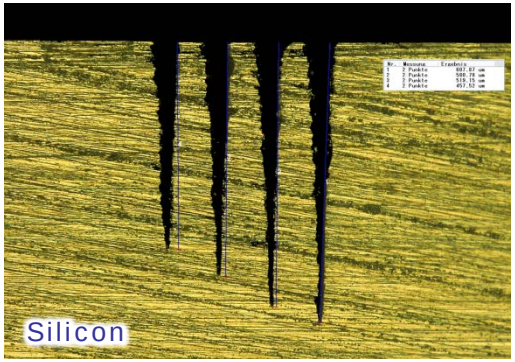


Pulsed Fiber Laser in Micromachining

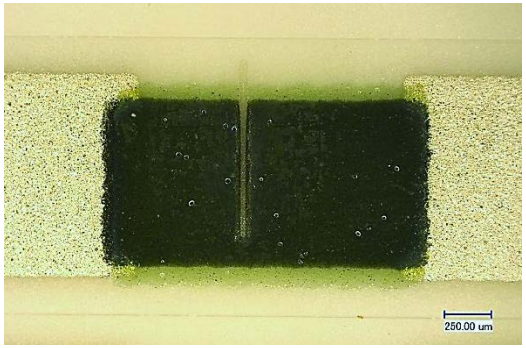
MOPA (Master Oscillator Power Amplifier)

Application Example

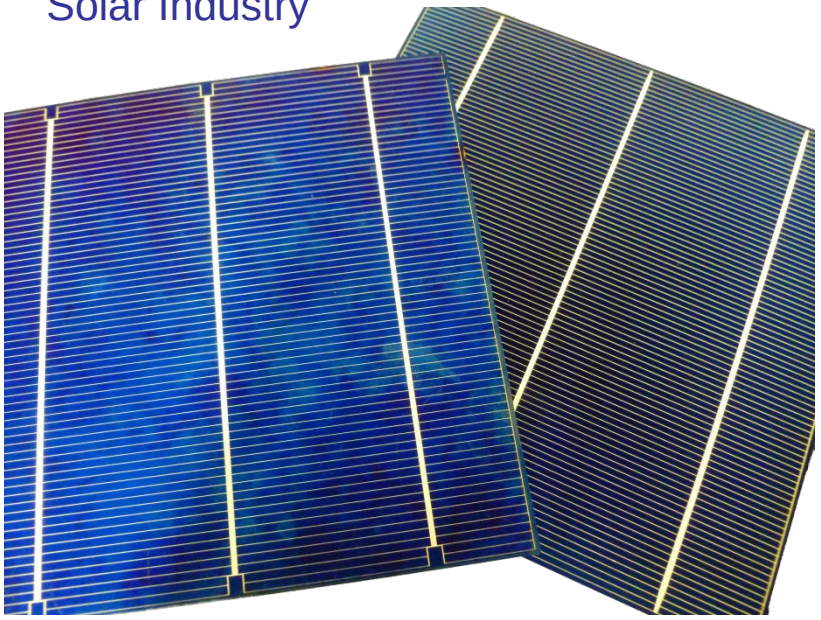
Scribing



Resistance trimming



Solar Industry

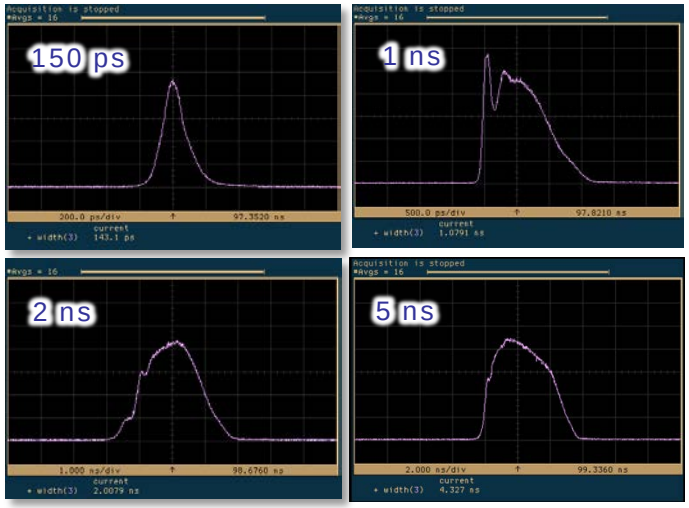


- Open of Passivation - Layer
- Scribing
- Drilling

Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

- Fine Ablation
- Dark Marking
- Scribing
- Precision Hole Drilling



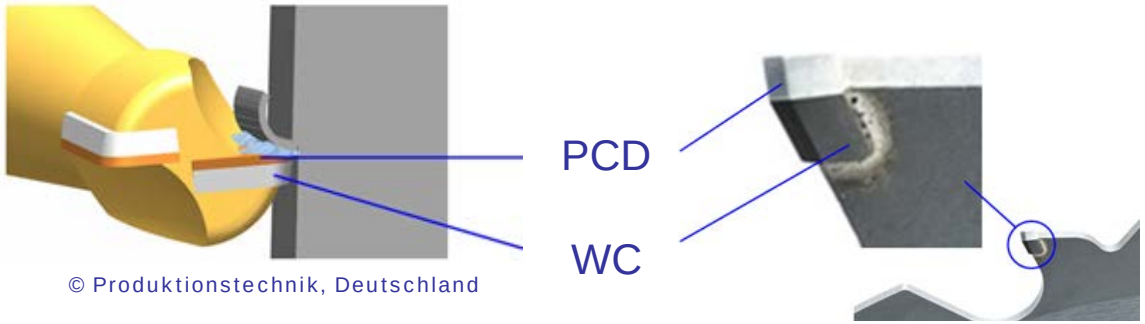
- Peak power — up to 330 kW
- Average power — 30 W
- Pulse energy — up to 1 mJ
- Pulse repetition rate — 2…1000 kHz
- Pulse duration — 0.15…5 ns
- Beam diameter — 7.5 mm
- Beam quality M2 — <2
- Delivery fiber length — 5 m
- Operating wavelength — 1064 nm
- Size module (WxHxL) — 215x95x286 mm
- Size head (WxHxL) — 162x70x320 mm

Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

Application Example

Cutting of PCD (PolyCrystalline Diamond) and Tungsten-Carbide (WC)



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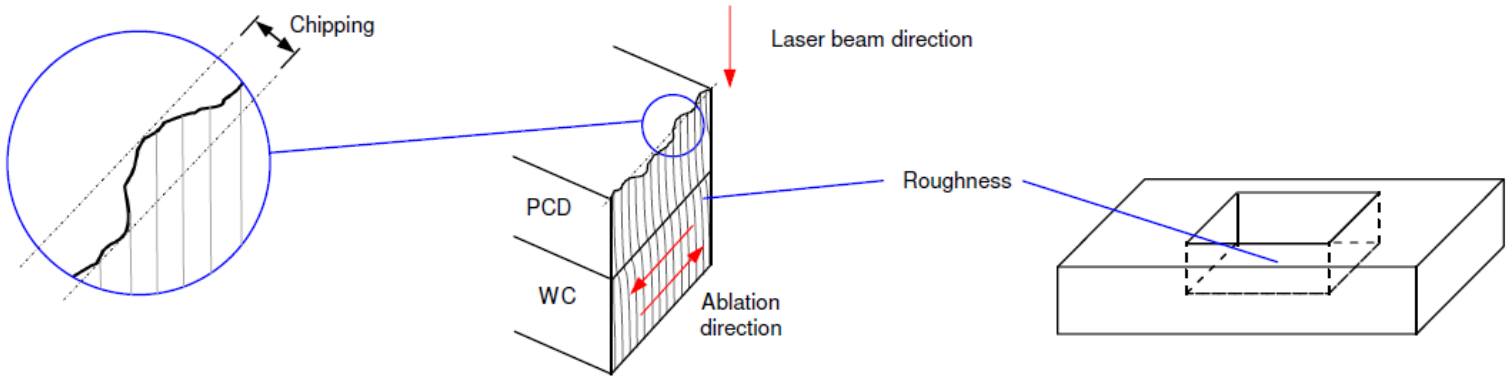
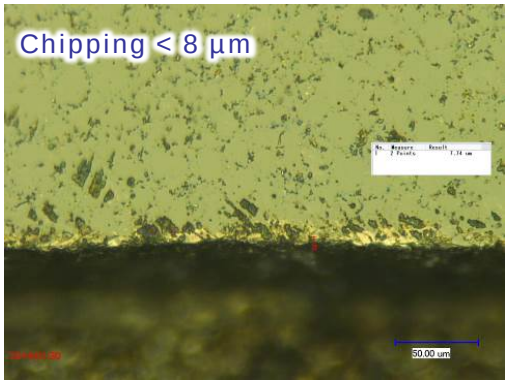


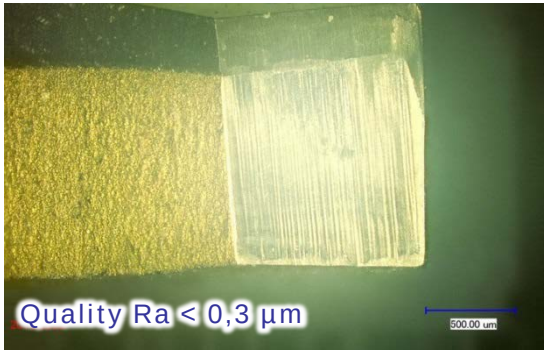
Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

Application Example

Cutting of PCD (Poly Crystalline Diamond) and Tungsten-Carbide (WC)





Process Results:

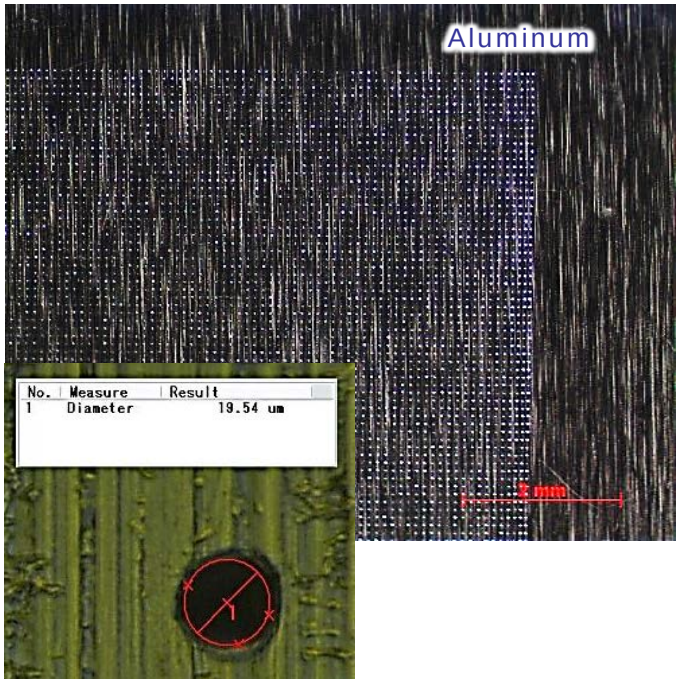
- less roughness on cut edge wall (Ra = 0.2 – 0.3µm)
- less chipping (<8µm)
- no heat affected zone
- ablation rate ~ 1mm³/min
- 2 step process:
  5ns/1mJ for deep engraving
  150ps/50µJ for fine finish

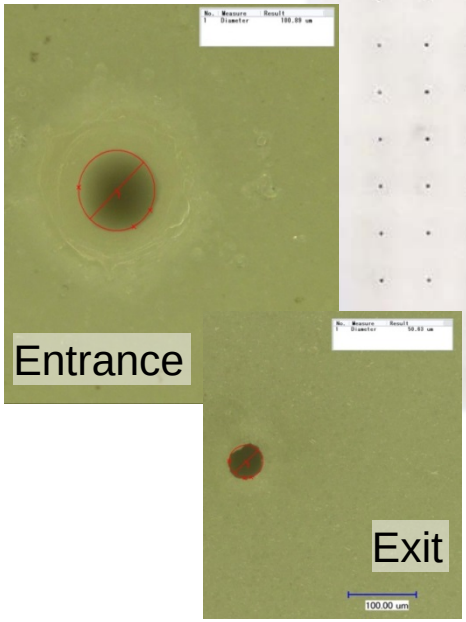
Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

Application Example

Drilling





- Less heat input
- Constant holes in ceramic
- High aspect ratio

Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

Application Example

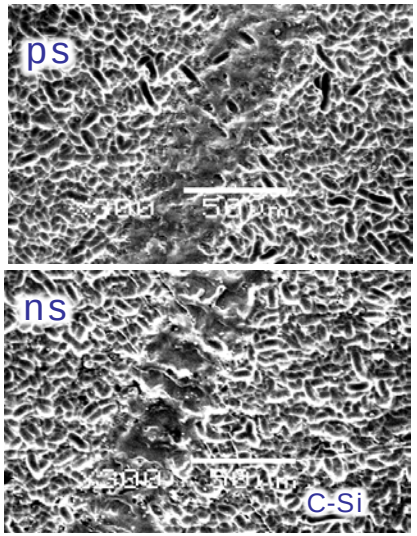
Dark marking of different Material

- Copper
- Aluminum
- Steel
- Brass
- Coated Material
- Synthetic Material
- …

Pulsed Fiber Laser in Micromachining

Pico Second Fiber Laser

Application Example



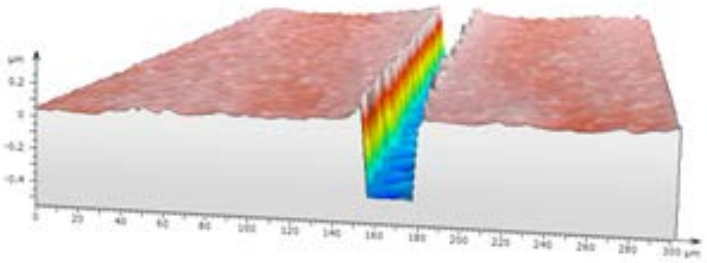
Example c-Si PV Selective Removal of Backside Passivation

- no melting with 150ps
- no heat affected zone

Thin Layer Technology

- Solar cells(c-si)
- Molybdenum layer
- CIGS(copper- indium-gallium-selenide
- ITO(indium tin oxide)
- PEDOT(Poly(3,4-ethylenedioxythiophene))
- …

Example P1 on flexible substrate



Outlook & Conclusion

- IPG is market leader for fiber lasers
- Single mode lasers for fine cutting and micro welding applications
- QCW lasers to replace lamp pumped Nd:YAG lasers
- Pulsed lasers in ns range for a broad range of micromachining applications
- Sub ns fiber lasers are a cost efficient alternative for ultra short pulse lasers for many applications

Thank you for your attention!

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